Battery Secrets

Lecture by

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Images that Accompany the Lecture

The following 7 images are used in the lecture to illustrate certain aspects of the chemistry of the Lead Acid Battery. The images in the video presentation are sometimes difficult to see because of the lighting in the auditorium. This image file reproduces these images to promote clarity in the lecture.

Special Note:

When watching the video file, it is necessary to reset the "Aspect Ratio" in your video player to normalize the picture. Depending on your video viewer, this Aspect Ratio may need to be reset to some setting between "16:9" or as high as "2.35:1". The correct Aspect Ratio for your viewer will make the wheel seen in the opening sequence perfectly round.

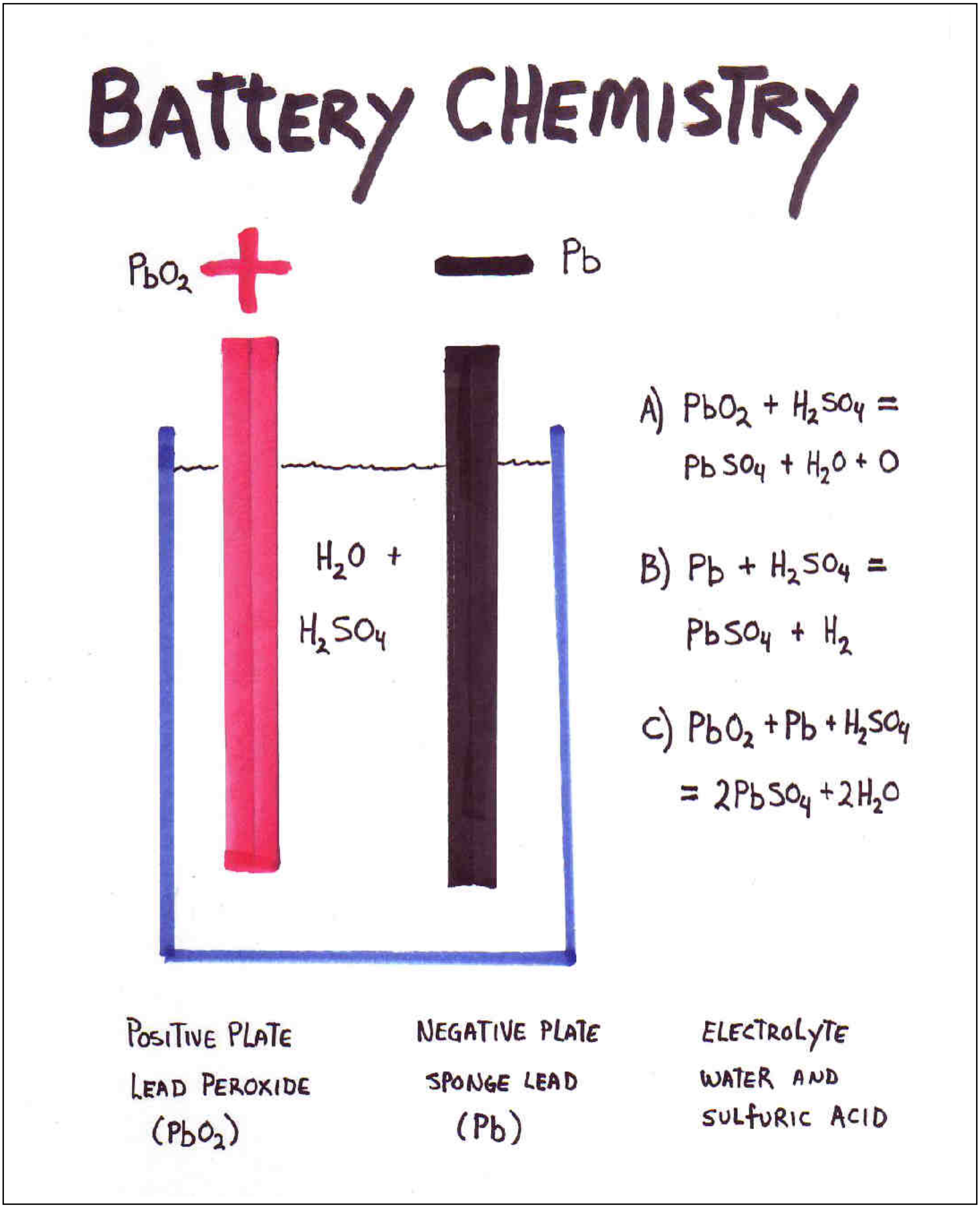


Figure 1. Battery Chemistry

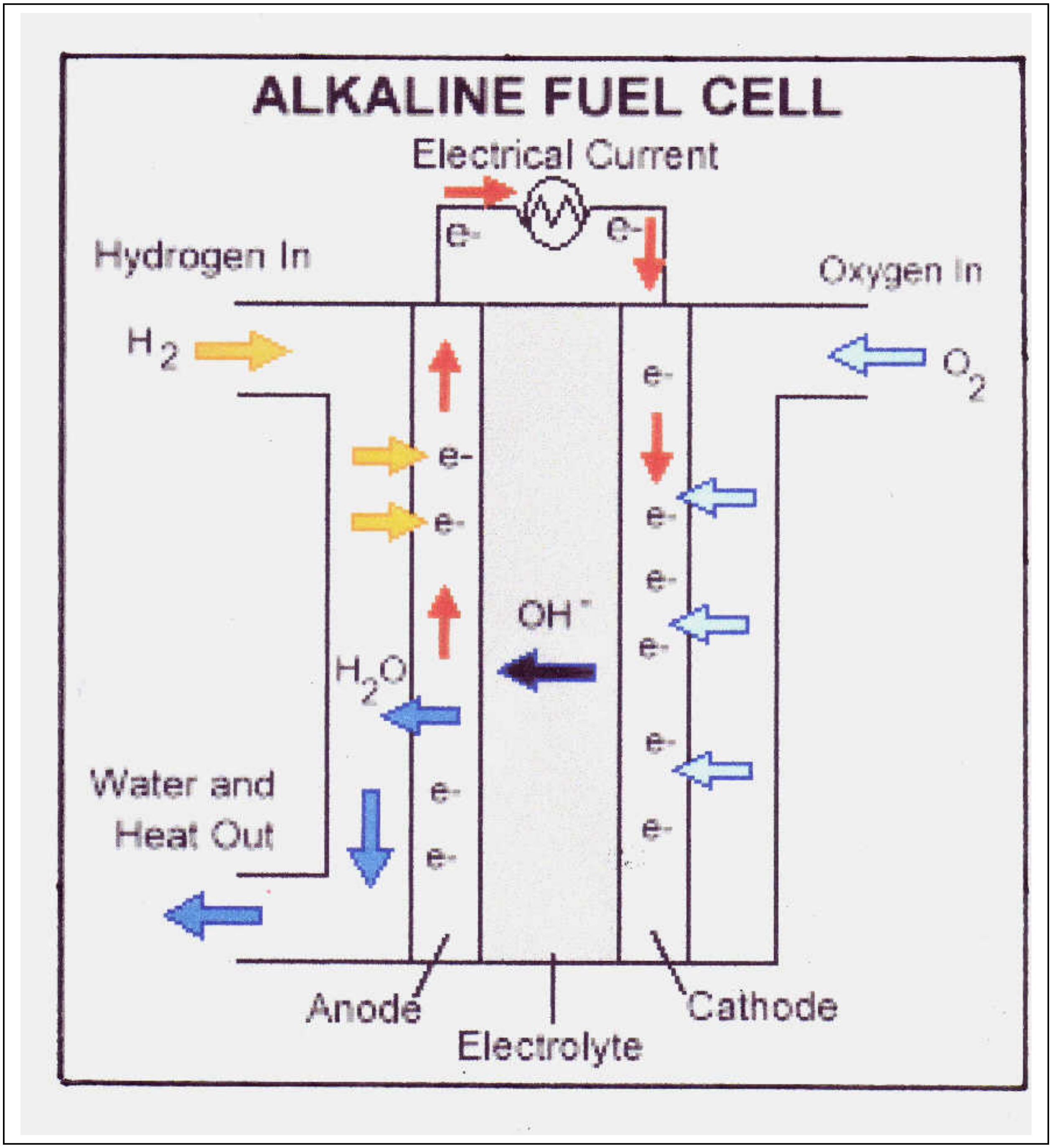


Figure 2. Alkaline Fuel Cell

Let us now consider a single storage cell made up of electrolyte, one positive plate, and one negative plate. When this cell is fully charged, or in a condition to produce a current of electricity, the positive plate is made up of peroxide of lead (PbO_2), the negative plate of pure lead (Pb), and the electrolyte of dilute sulphuric acid (H_2SO_4). This is shown diagrammatically in Fig. 19. **The chemical changes that take place when the cell is discharging and the final result of the changes are as follows:**

(a). At the Positive Plate: Lead peroxide and sulphuric acid produce lead sulphate, water, and oxygen, or:

$$\text{(a).}\quad PbO_2 + H_2SO_4 = PbSO_4 + H_2O + O$$

(b). At the Negative Plate: Lead and sulphuric acid produce lead sulphate and Hydrogen, or:

$$\text{(b).}\quad Pb + H_2SO_4 = PbSO_4 + H_2$$

The oxygen of equation **(a)** and the hydrogen of equation **(b)** combine to form water, as may be shown by adding these two equations, giving one equation for the entire discharge action:

$$\text{(c).}\quad PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O$$

In this equation we start with the active materials and electrolyte in their original condition, and finish with the lead sulphate and water, -which are the final products of a discharge. Examining this equation, we see that the sulphuric acid of the electrolyte is used up in forming lead sulphate on both positive and negative plates, and is therefore removed from the electrolyte. This gives us the easily remembered rule for remembering discharge actions, which, though open to question from a strictly scientific viewpoint, is nevertheless convenient:

During discharge the acid goes into the plates.

The chemical changes described in **(a)**, **(b)**, and **(c)** are not instantaneous. That is, the lead, lead peroxide, and sulphuric acid of the fully charged cell are not changed into lead sulphate and water as soon as a current begins to pass through the cell. This action is a gradual one, small portions of these substances being changed at a time. The greater the current that

Figure 3. Formula Page

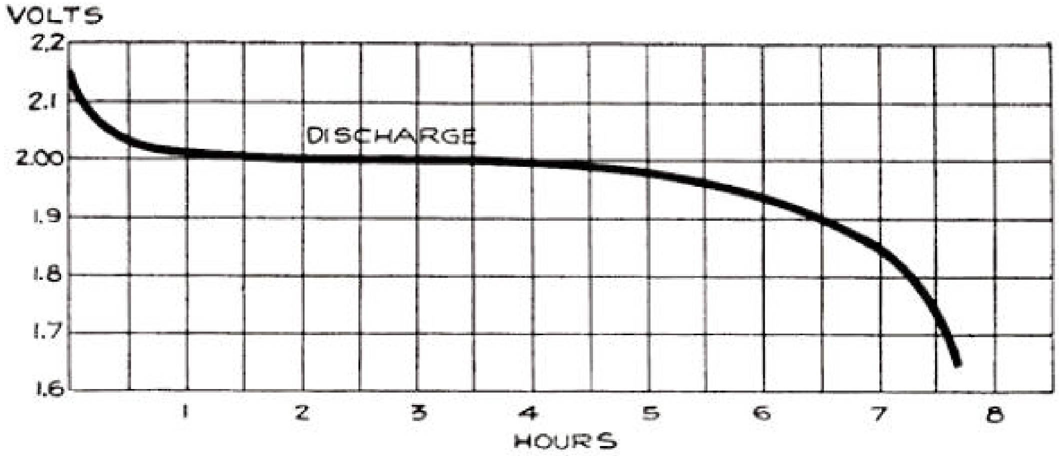


Fig. 22. Voltage Changes During Discharge

Figure 4. Discharge Graph

CHAPTER 6

WHAT TAKES PLACE DURING CHARGE

Voltage. Starting with a battery which has been discharged until its voltage has decreased to 1.7 per cell, we pass a current through it and cause the voltage to rise steadily. Fig. 24 shows the changes in voltage during charge. Ordinarily the voltage begins to rise immediately and uniformly. If, however, the battery has been left in a discharged condition for some time, or has been "over discharged," the voltage rises very rapidly for a fraction of the first minute of charge and then drops rapidly to the normal value and thereafter begins to rise steadily to the end of the charge. This rise at the beginning of the charge is due to the fact that the density of the acid in the pores of the plates rises rapidly at first, the acid thus formed being prevented from diffusing into the surrounding electrolyte by the coating of sulphate. As soon as this sulphate is broken through, diffusion takes place and the voltage drops.

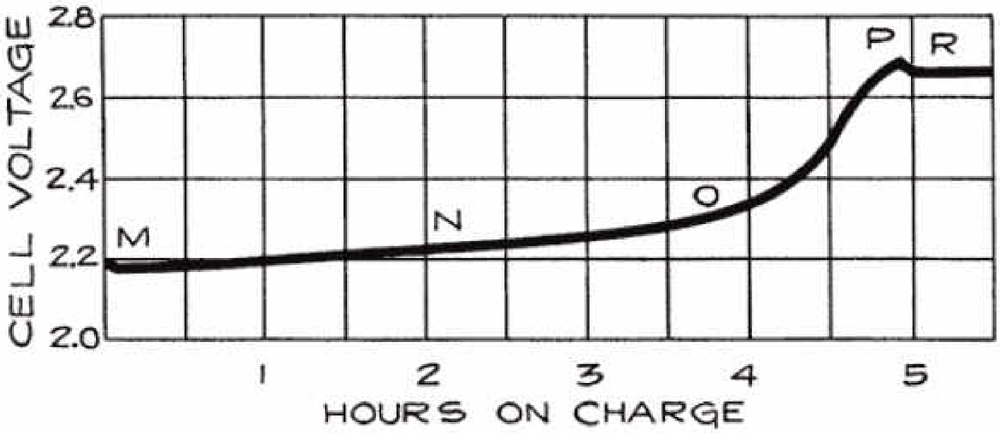


Fig. 24. Voltage Changes During Charge

As shown in Fig. 24, the voltage remains almost constant between the points M and N. At N the voltage begins to rise because the charging chemical reactions are taking place farther and farther in the inside parts of the plate, and the concentrated acid formed by the chemical actions in the plates is diffusing into the main electrolyte. This increases the battery voltage and requires a higher charging voltage.

At the point marked 0, the voltage begins to rise very rapidly. This is due to the fact that the amount of lead sulphate in the plates is decreasing very rapidly, allowing the battery voltage to rise and thus increasing the charging voltage. Bubbles of gas are now rising through the electrolyte.

Figure 5. Charge Graph

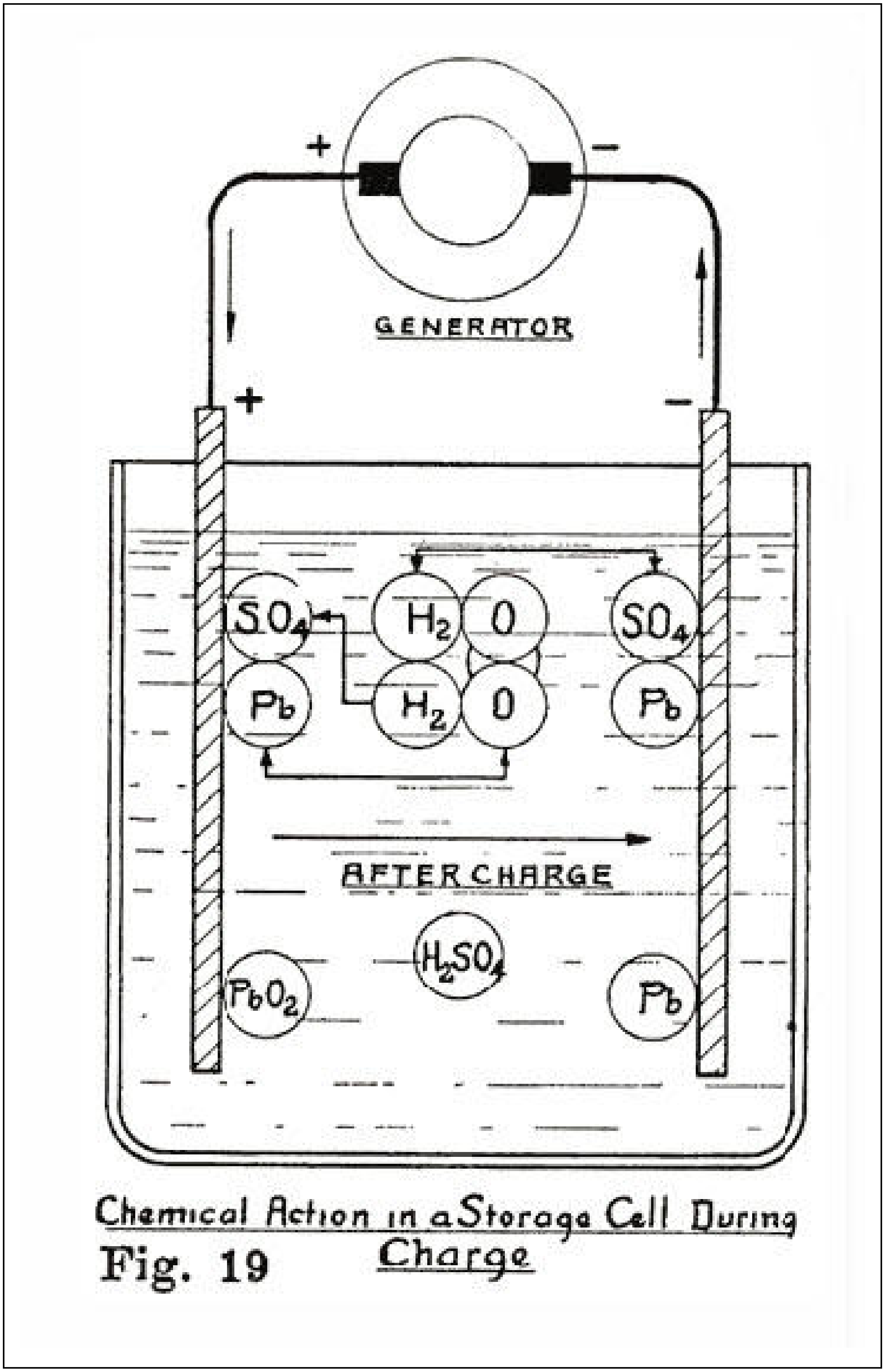
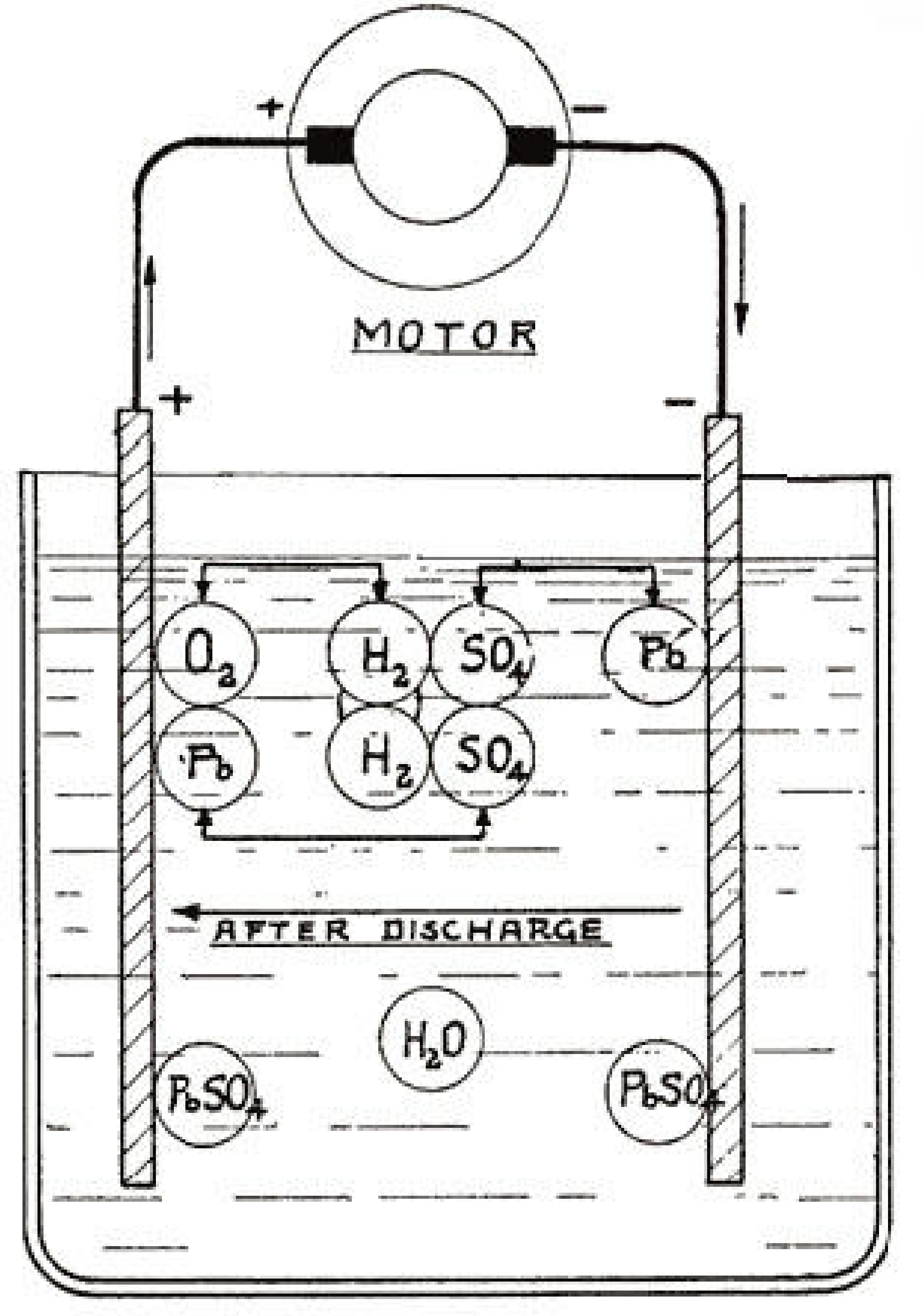


Figure 6. Chemical Charge



Chemical Action in a Storage Cell During Discharge

Fig. 20

Figure 7. Chemical Discharge